POPULATION ESTIMATE OF CHINOOK SALMON ESCAPEMENT IN THE CHENA RIVER IN 1988 BASED UPON MARK AND RECAPTURE TECHNIQUES

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ABSTRACT

Gill nets of two different mesh sizes and electroshocking were used to capture adult chinook salmon (Oncorhynchus tshawytscha Walbaum) to estimate total escapement using mark and recapture techniques. A total of 254 gill net caught chinook salmon was tagged, finclipped and released, while an additional 128 were tagged, finclipped and released which were captured by electroshocking. Eight-two marked fish were subsequently recovered from a total of 1,018 fish and carcasses examined on the spawning grounds. Tag loss was estimated to be 20%.

It was found when using gillnet data that probabilities of recapture were not constant over the period of release, thus a Petersen-type population estimate could not be made. Further, approximately 15 different models were examined, using stratified population estimators, but without success. It was not possible to estimate population size with the gillnet data. Ten additional models were also examined by pooling the electoshocking data with gillnet data; again without success.

A modified Petersen estimate of 3,045 chinook salmon with an approximate 95% confidence interval of ± 1,100 fish was obtained for a portion of the river when using electroshocking data. This estimate was expanded, using aerial survey observations on fish distribution, to a total river escapement of 3,346 chinook salmon. An aerial census flown under fair survey conditions during the period of peak spawning accounted for approximately 59% of the expanded population estimate.

Overall mean timing of the chinook salmon run in the Chena River was estimated to be 17 July with 50% run passage estimated on 18 July. A slight difference in timing by sex was observed.

The chinook salmon spawning population was composed of 6 age groups from 6 brood years. Females were dominated by age groups 1.4 (36%) and 1.5 (21%), whereas males were predominantly represented by age groups 1.2 (11%), 1.3 (14%), and 1.4 (11%). The chinook salmon escapement male-to-female ratio was estimated at 1.00:1.56.

KEY WORDS: chinook salmon, Oncorhynchus tshawytscha, population estimate, mark and recapture, escapement, aerial census, Yukon River, Tanana River, Chena River.

INTRODUCTION

The Yukon River drainage is too extensive in size for a practical, complete escapement enumeration program during any given year. Consequently, low-level aerial surveys have been the primary method used to obtain escapement information on salmon stocks throughout the drainage. It is known however, that aerial surveys underestimate total spawner abundance due to the die-off of early spawners and arrival of late spawners (Bevan 1961, Neilson and Geen 1981, Cousens et al. 1982, Barton 1986). As a consequence, the existing data base on chinook salmon reflects trends in escapements based upon the relative abundance of spawners but does not portray total escapement abundance. A need exists to develop expansion factors which can be applied to aerial survey results in order to project total spawning abundance.

The Chena River, one of the most important chinook salmon producing streams in the Yukon River drainage, was selected for a third year of study in 1988 (Figure 1). Results from 1986 and 1987 investigations can be found in Barton (1987a, 1988). The river is located in the Yukon Plains section of the Central Alaskan Upland and Plains Province. More specifically, it lies in the Tanana Basin, heading south and east of the White Mountains in the North Plateau Province, through which it flows in a westerly direction for approximately 150 miles draining an area of approximately 1,980 square miles (Frey et al. 1970, Anderson 1970).

The Chena River typifies many of the larger chinook salmon producing streams in the Alaskan portion of the drainage in terms of the relative magnitude of observed spawners (e.g., Andreafsky, Anvik, Nulato and Salcha rivers). Since 1979, peak aerial survey indices of Chena River chinook salmon escapement have ranged from 501 to 2,553 fish with a 10-year average of 1,728 fish (Whitmore et.al. 1988).

By obtaining a total estimate of chinook salmon escapement in the Chena River, the proportion represented by a peak aerial census can be estimated. This will in turn permit expansion of past aerial survey escapement records to total abundance estimates. Hopefully, results will also be useful in expanding historic aerial escapement records for other important chinook salmon producing streams throughout the drainage which are similar in physical and hydrological nature.

Funding for the Chena River study was provided in part by a federal grant in support of U.S./Canadian Yukon River negotiations as they pertain to the Pacific Salmon Treaty of 1985 and in part by the State of Alaska.

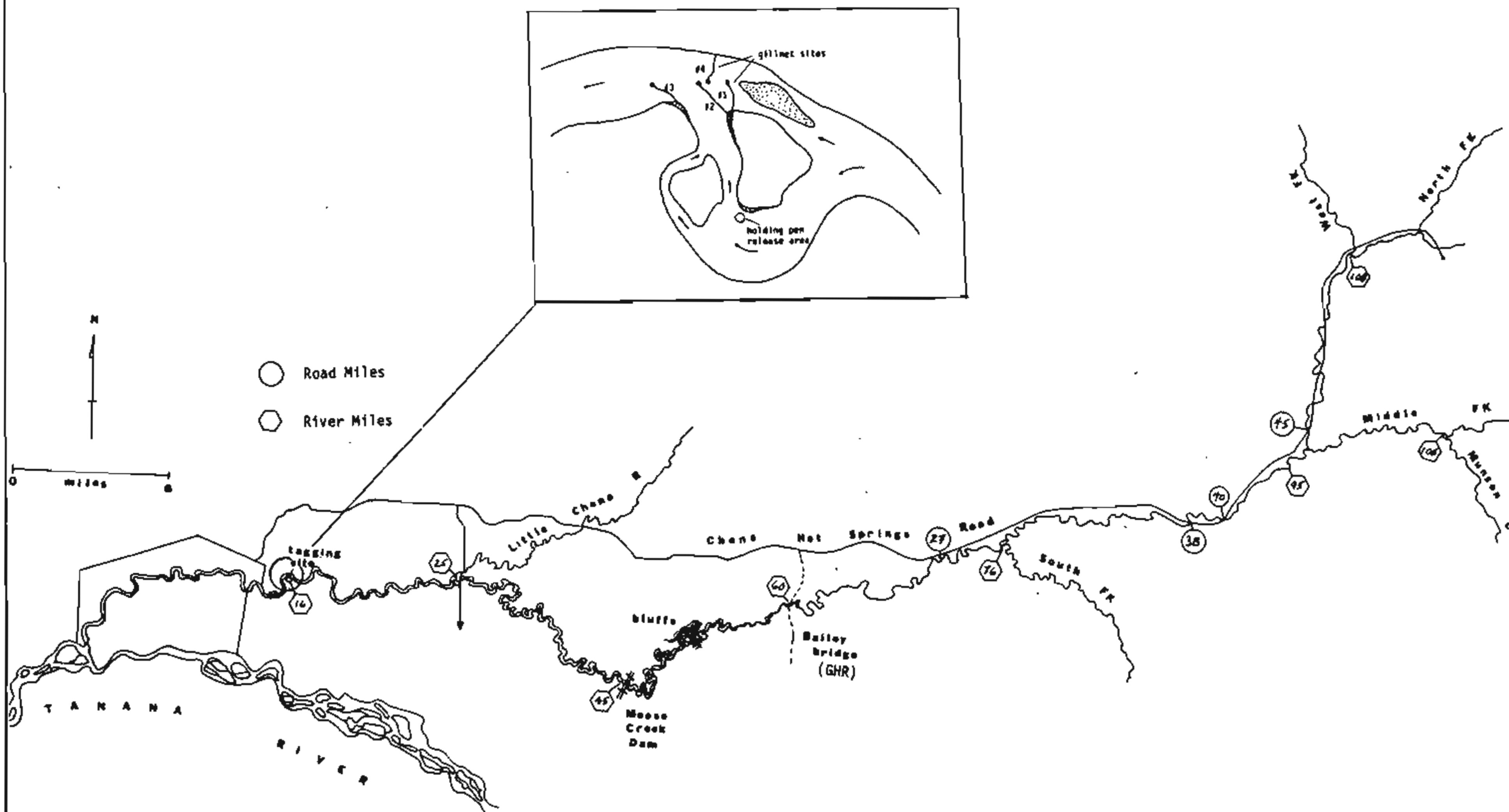

Figure 1. The Chena River drainage and gill net tagging site for the 1988 mark-recapture project.

OBJECTIVES

Overall objectives of the 1988 Chena River chinook salmon study were to determine timing and magnitude of chinook salmon escapement and to estimate the proportion of the spawning population observed by a peak aerial census. The following specific objectives were identified:

1. Estimate the size of the Chena River chinook salmon spawning population using mark and recapture methods.
2. Estimate the proportion of the total Chena River chinook salmon escapement represented by an aerial survey point estimate during peak spawning.
3. Determine escapement timing of chinook salmon spawners in the Chena River.
4. Estimate the age, sex, and size composition of chinook salmon escapement in the Chena River.
5. Support ongoing chinook salmon stock separation studies based upon scale pattern analysis (SPA) and protein-gel electrophoretic analysis by collecting scales and tissue/organ samples.

MATERIALS AND METHODS

Test Fishing and Tagging

Two mesh size gill nets (5-3/4 and 8-1/8 inch stretch measure) were fished daily at rivermile 16 of the Chena River to collect chinook salmon for tagging (Figure 1). Three gill nets were fished at locations used in both 1986 and 1987: two 60-foot long by 15-foot deep chum salmon nets (5-3/4 inch mesh) and one 90-foot long by 20-foot deep chinook salmon net (8-1/8 inch mesh). An additional chinook salmon net was fished later in the season. Each net was constructed of multifilament nylon with half-inch braided filament core floatlines and oval grommeted floats. Leadlines were approximately 110 pounds per 100 fathoms.

When deployed, all nets were fished during the same approximate 8-hour period (0800-1600 hours) each day to examine run timing using catch per unit effort (CPUE) data. Catch per unit effort was defined as the number of salmon captured per gill net hour per net. Additional fishing time was periodically allocated throughout the tagging period to maximize the number of chinook salmon tagged. Daily records were maintained documenting the duration of each gill net set by mesh size and resulting catch by species.

A two-person crew monitored gill nets continually by riverboat. When a fish was captured in a net, as evidenced by bobbing cork(s) in the floatline, the crew pulled alongside the net, removed the fish and placed it into a 50 gallon holding tank in the riverboat.

Additional adult chinook salmon were captured for tagging using a riverboat equipped with electrofishing gear (Roguski and Winslow 1969). Fish were stunned with pulsating direct current electricity, dipped from the river with long handled nets, and placed in an aerated holding box.

All chinook and chum salmon (O. keta Walbaum) captured were sexed by external examination and measured to the nearest 5 millimeters from mid-eye to fork of tail. A numbered, orange spaghetti tag was secured in place immediately anterior to the dorsal fin on each chinook salmon captured prior to its release. In addition, each chinook salmon was marked with a combination of adipose, anal, and pelvic finclips which would identify its capture and release date to within 5 days. No chum salmon were tagged but the adipose fin was removed to identify recaptures. The marking schedule for gill net caught chinook salmon was as follows:

< 5 July	Adipose plus anal finclip
5 - 11 July	Adipose plus left pelvic finclip
12 - 18 July	Adipose plus right pelvic finclip
19 - 25 July	Adipose finclip only
> 25 July	Adipose plus right and left pelvic finclip

In addition to the above marking schedule, all chinook salmon captured by electroshocking were marked with only a right pelvic finclip after tag application.

Upon completion of sampling (and tagging in the case of chinook salmon), fish were released approximately 100 yards upstream of the test fishing site. A four foot square holding pen was constructed and utilized when necessary to ensure fish were released in a vigorous state.

Tag Recovery

Spawning ground surveys were conducted daily by riverboat to examine chinook salmon carcasses for tags subsequent to the test fishing portion of the study. The spawning area examined was from Moose Creek Dam (MCD) to approximately three miles up the

Middle Fork river. All chinook salmon carcasses were collected using long handled spears, examined for tags and finclips, sexed by external examination, and measured from mid-eye to fork of tail to the nearest 5 mm. All tags were removed and the date, recovery location, tag number, and finclip combination carefully recorded for each fish.

Additional tag recoveries were made between rivermiles 68 and 72 using an electroshocking boat with assistance from the Division of Sport Fisheries.

Other biological sampling associated with spawning ground surveys included collecting scales (3 per fish) from a random sample of 500 chinook salmon to estimate age composition of the escapement and to provide samples for use in subsequent stock separation studies. From the sample of 500 chinook salmon, tissue/organ samples (eye, heart, and muscle) were collected on 100 fish with assistance of the U.S. Fish and Wildlife Service (USFWS) for subsequent use in genetic stock identification studies (GSI). These 100 chinook salmon were those collected by electrofishing between rivermiles 68 and 72. Results associated with SPA and GSI sampling will be reported separately.

Abundance Estimators

Several statistical tests were conducted during data analyses to determine the most appropriate abundance estimator of Chena River chinook salmon spawners in 1988. Those statistical tests as well as abundance estimators used are presented in the "Results and Discussion" section of this report.

Aerial Surveys

Attempts were made to survey Chena River spawning areas by single engine, fixed-wing aircraft throughout the chinook salmon spawning season. The number of live and dead salmon by species was recorded as well as survey conditions and overall survey effectiveness (i.e., a subjective rating of overall survey quality as good, fair, or poor) (Barton 1987b). Counts were recorded by river index area for each survey flown:

- Downstream of MCD
- MCD to confluence of South Fork
- Confluence of South Fork to confluence of Middle Fork
- Confluence of Middle Fork to confluence of West Fork
- Middle Fork from mouth upstream to confluence of Munson Cr

The primary index area for assessing whether or not the chinook salmon escapement objective (1,000 - 1,700) is met in the Chena River is that portion of the mainstem river between MCD and confluence of the Middle Fork. The escapement objective is based upon aerial survey estimates made during the peak of spawning which do not represent total escapement, but do reflect annual spawner abundance trends when using standard survey methods under acceptable survey conditions.

RESULTS AND DISCUSSION

Tagging

Test fishing was initiated at rivermile 16 on a temporary basis on 23 June. One chinook salmon net was fished at site 2 for approximately 2-5 hours per day prior to 2 July. Purpose of the early test netting was to monitor arrival time of the chinook salmon run. Although the first chinook salmon captured was on 29 June, the first report of chinook salmon present in the Chena River was on 28 June when a sport fishermen reported observing one roll at approximately rivermile 15. Subsequent to 2 July attempts were made to consistently fish gill nets each day during the "standard" 8-hour period to examine run timing. Periodically fishing time was increased to approximately 10 to 16 hours per day as catches started to build in mid July. A total of 258 chinook and 98 chum salmon were captured (Table 1 and Appendix A). Other species captured during the tagging portion of the studies included 1 sheefish (Stenodus leucichthys Pallas).

The small mesh or chum gear was not as effective in capturing chinook salmon as in past years due to higher water conditions which persisted in 1988. The high water and accompanied increased currents and debris did not permit the small mesh gear to fish efficiently. This gear accounted for only 15% of the chinook salmon captured and 83% of the chum salmon captured. By comparison, small mesh nets accounted for 25% and 58% of the total chinook salmon captured in 1987 and 1986, respectively (Barton 1988, 1987). Of the chinook salmon captured in small mesh nets in 1988, 79% were males while 74% of the chum salmon captured in small mesh gear were males. The larger, chinook gear captured 85% of the chinook salmon, of which 32% were males. Only 17 chum salmon (15 males and 2 females) were captured with large mesh gear.

Test net recaptures amounted to only 3 chinook and no chum salmon during the tagging portion of the study. Documented mortalities were 4 chinook (1.6%) and 1 chum (1.0%) salmon.

Table 1. Daily catches of chinook and chum salmon in test gill nets in the Chena River, 1988. a

Date	Net Sites Fished	Approx. Hours Fished	Chinook Salmon Catch				Remarks	Chum Salmon Catches				Remarks
			Male	Female	Total	Cum.		Male	Female	Total	Cum.	
23-Jun b	2	4.50	0	0	0	0		0	0	0	0	
24-Jun b	2	1.50	0	0	0	0		0	0	0	0	
25-Jun		0.00				0		0	0	0	0	
26-Jun		0.00				0		0	0	0	0	
27-Jun b	2	2.00	0	0	0	0		0	0	0	0	
28-Jun b	2	4.50	0	0	0	0		0	0	0	0	
29-Jun b	2	2.50	0	1	1	1		0	0	0	0	
30-Jun b	2,3	4.75	0	0	0	1		0	0	0	0	
01-Jul b	2	4.57	0	0	0	1		0	0	0	0	
02-Jul	2,3	8.00	1	1	2	3		0	0	0	0	
03-Jul		0.00				3		0	0	0	0	
04-Jul		0.00				3		0	0	0	0	
05-Jul	1,2,3	6.50	2	1	3	6		1	1	2	2	
06-Jul	1,2,3	8.00	3	1	4	10	1 recap	0	1	1	3	
07-Jul	1,2,3	8.00	8	5	13	23	1 recap	1	0	1	4	
08-Jul	1,2,3	9.50	1	2	3 (2)	26		4	0	4 (4)	8	
09-Jul	1,2,3	11.00	6	3	9 (8)	35	1 sheefish	4	0	4 (2)	12	
10-Jul	1,2,3	8.00	3	1	4	39		0	0	0	12	
11-Jul	1,2,3	8.00	4	3	7	46	1 recap	1	0	1	13	
12-Jul	1,2,3	8.00	4	2	6	52		0	0	0	13	
13-Jul	1,2,3,4	14.00	10	8	18 (12)	70	1 mort	1	0	1	14	
14-Jul	1,2,3,4	8.00	5	11	16	86		1	1	2	16	1 mort
15-Jul	1,2,3,4	8.00	5	16	21	107		0	1	1	17	
16-Jul	1,2,3,4	8.00	7	5	12	119		2	0	2	19	
17-Jul	1,2,3,4	8.00	4	7	11	130	2 morts	0	4	4	23	
18-Jul	1,2,3,4	16.00	8	17	25 (15)	155		8	1	9 (7)	32	
19-Jul	1,2,3,4	6.50	5	9	14	169		5	1	6	38	
20-Jul	1,2,3,4	8.00	4	10	14	183		1	0	1	39	
21-Jul	1,2,3,4	8.00	8	15	23	206		10	6	16	55	
22-Jul	1,2,3,4	9.00	4	15	19 (19)	225		11	1	12	67	
23-Jul	1,2,3,4	8.00	2	9	11	236		7	3	10	77	
24-Jul	1,2,3,4	8.00	2	9	11	247		0	0	0	77	
25-Jul	1,2,3,4	8.00	3	3	6	253	1 mort	6	1	7	84	
26-Jul	1,2,3,4	8.00	0	2	2	255		11	2	13	97	
27-Jul	1,2,3,4	8.00	1	2	3	258		1	0	1	98	
Totals		232.82	100	158	258		4 morts	75	23	98		1 mort

a Number of chinook salmon successfully tagged and released (254) equals cumulative catch minus 4 mortalities.
Numbers in parentheses indicate chinook salmon captured during the 8-hour period of approximately 0800-1600 hrs.

b Days on which high water affected number, location and duration of nets fished.

All 258 chinook salmon captured were measured and sexed. The male to female ratio was 1.00:1.58 (39% males; 61% females). A total of 254 chinook salmon were successfully tagged, finclipped and released throughout the period 23 June through 27 July with the first release made on 29 June. The number of chum salmon which were sexed, measured, finclipped and released totaled 97 (77% males; 23% females).

On July 25 electroshocking was used to capture and deploy an additional 128 tagged chinook salmon. This technique was used due to concern over the low number of tags which had been deployed by this date using gill nets. Shocking and tagging occurred between rivermile (RM) 89 and the confluence of the South Fork river (RM 76). Sex ratio was 61% males and 39% females.

Tag Recovery

Portions of the Chena River salmon spawning grounds were examined daily from 29 July through 12 August. Two complete surveys were conducted of the spawning grounds between MCD (RM 45) and approximately 3 rivermiles up the Middle Fork river (RM 100). A total of 919 chinook salmon carcasses was examined for tags and finclips. Length and sex were recorded for 890 of these fish, while 29 were neither sexed nor measured due to their state of decomposition. The male to female ratio from 890 carcasses was 1.00:1.58 (39% male and 61% female). An additional 99 chinook salmon were collected between RM 68 and RM 72 on 29 July by electroshocking. Length and sex were recorded for all of these fish. The male to female ratio was 1.00:0.94 (52% male and 48% female).

A random sample of 500 fish (collected from both carcass surveys and electroshocking) were scale sampled for subsequent aging. Scale age determination from 468 readable scales indicated that chinook salmon were represented by 6 age groups from 6 brood years (Table 2). The male to female ratio for the ageable samples (n = 468) was 1.00:1.55 (39% males; 61% females), basically the same as that for gill net releases.

A total of 82 marked chinook salmon (22 males and 60 females) was recovered; 66 with a tag and 16 which had lost tags but were identified by finclips. Tag loss was approximately 20% (7 males and 9 females).

Table 2. Age and sex composition of chinook salmon sampled in the Chena River in 1988.

Sample Size		Brood Year and Age Group [a] 1985	1984	1983	1982	1981	1980	
		1.1	1.2	1.3	1.4	1.5	2.5	Total
285	Females	0.0	0.0	3.6	35.5	21.4	0.4	60.9
183	Males	0.6	10.5	13.9	10.9	3.2	0.0	39.1
468	Combined	0.6	10.5	17.5	46.4	26.4	0.4	100.0
	SE	1.7	6.6	8.2	10.8	9.3	1.4	

a Age is designated as European: number of freshwater annuli followed by number of saltwater annuli.

Aerial Surveys

Four aerial surveys were attempted of the Chena River in 1988 to enumerate salmon escapement. Surveys were flown on 16, 19, 20, and 27 July. The 16 July survey was soon aborted due to heavy cloud cover and turbulence as well as high and muddy water conditions. No reliable counts were possible. The 19 July survey was incomplete as only the Chena River upstream of the South Fork river confluence was surveyed. A total of 455 live chinook salmon were counted of which 50 were observed in the mainstem Chena River upstream of the confluence of the Middle Fork river.

The survey on 20 July was given an overall rating of "fair". This less than "good" survey rating resulted primarily from scattered cloud cover and slight turbidity of river water. A total of 1,966 chinook salmon (1,953 live and 12 dead) and 164 chum salmon were observed. Chinook salmon distribution was as follows:

- MCD to South Fork - 990 (50%)
- Confluence South Fork to confluence Middle Fork - 653 (33%)
- In Middle Fork upstream to Munson Creek - 323 (16%)

A second surveyor flew the Chena River on 27 July and counted 1,879 chinook salmon (1,780 live and 99 dead) and 432 live chum salmon. The survey was rated "good" for chinook and "poor" for chum salmon. Chinook salmon distribution was as follows:

- MCD to GHR - 162 (9%)
- GHR to confluence South Fork - 893 (47%)
- Confluence South Fork to confluence Middle Fork - 705 (38%)
- In Middle Fork upstream to Munson Creek - 119 (6%)
  (includes 15 between Middle Fork confluence and 4th bridge)

Weather and water conditions were not conducive for conducting more aerial surveys in 1988 during the chinook salmon spawning season.

Analysis of Gill Net Tagging Data

Two instances occurred when the sex of a tagged fish recovered during carcass surveys was different from that recorded at the time of release. The sex for these two fish was changed to that identified during carcass surveys since it is probable that sex can be more accurately determined from carcasses (i.e., gonads can be inspected).

Since length was recorded for tagged fish recovered during carcass surveys as well as at time of release, a comparison was made between the two measurements. For the release-recovery length analysis, all chinook salmon recovered with a tag during carcass surveys were used as well as fish originally captured in gill nets and fish originally captured by electroshocking (Appendix B). First, the method of capture (gill net versus electroshocking) was examined to see if either affected the relationship between release and recovery lengths. Each sex was analyzed separately.

The relationship between length at release and length at recovery was tested by comparing regression lines when coding method of capture as a dummy variable as described on pages 190-193 of Kleinbaum and Kupper (1978). The resulting analysis of variance (ANOVA) table from the regression was then used to test the hypothesis of coincident regression lines (i.e., do the lines have the same slope and intercept) for the two methods of capture. The hypothesis of coincident lines was not rejected ($P > 0.50$) for either sex, therefore, data from capture methods were pooled (Table 3). The same procedure was used to test if the relationship between the length at release and length at recovery was the same for females and males by coding sex as the dummy variable. The hypothesis of coincident lines for the two sexes was not rejected ($P > 0.49$), therefore, data for each sex were pooled to estimate the regression line (Table 3). A regression using the pooled data for both capture methods and combined sexes was then computed (Figure 2). The regression was significant (Table 3) and the slope of the line was significantly different ($P < 0.02$) from 1 (a slope of 1 would indicate the relationship between the two length measurements was 1 to 1). The residuals from the regression were examined graphically; no trends were evident.

The resulting regression was used to estimate the length at release from the length at recovery for untagged chinook salmon examined during recovery surveys (carcass plus electroshocking). The mean difference between the length at recovery and the estimated length at release for the 907 untagged fish measured during recovery surveys was 24.5 mm (standard error = 0.37). The difference in length measurements was attributed to erosion of the caudal fin during redd construction and defense.

Two tests were conducted to determine if release and recovery samples were random with respect to length of the fish as recommended by Seber (1982). The Kolmogorov-Smirnov (K-S) test (Conover 1980) was used to compare the cumulative distributions of the lengths of chinook salmon which were tagged and recovered and of untagged fish examined during carcass surveys to test the

Table 3. Results of the regressions of length at recovery on length at release for tagged chinook salmon from the Chena River in 1988. Regressions for the method of first capture (gillnet or electroshock) are compared by sex and the regression lines for each sex using the combined (gillnet and electroshock) data are compared.

Source[1]	df	Sum of Squares	Mean Square	F statistic	Probability
FEMALES[2]					
Regression (X_1)	1	85,331	85,331	196.6	0.000
Residual	46	19,966	434		
Regression (X_1,Z_1)	2	85,703	42,852	98.4	0.000
Residual	45	19,595	435		
Regression (X_1,Z_1,X_1Z_1)	3	85,797	28,599	64.5	0.000
Residual	44	19,501	443		
MALES[2]					
Regression (X_1)	1	156,373	156,373	306.9	0.000
Residual	12	6,115	510		
Regression (X_1,Z_1)	2	156,803	78,402	151.7	0.000
Residual	11	5,684	517		
Regression (X_1,Z_1,X_1Z_1)	3	157,556	52,519	106.5	0.000
Residual	10	4,932	493		
METHODS COMBINED[2]					
Regression (X_1)	1	287,678	287,678	630.4	0.000
Residual	60	27,381	456		
Regression (X_1,Z_2)	2	288,020	144,010	314.2	0.000
Residual	59	27,038	458		
Regression (X_1,Z_2,X_1Z_2)	3	288,977	96,326	214.2	0.000
Residual	58	26,081	450		

[1] X_1 = Measured length at recovery.
Z_1 = Capture method (gillnet or electroshock).
Z_2 = Sex (male or female).

[2] The test statistic to determine if regression lines are coincident is:

$$F = \frac{[SS(X,Z,XZ) - SS(X)]/2}{MS\ residual\ (X,Z,XZ)}.$$

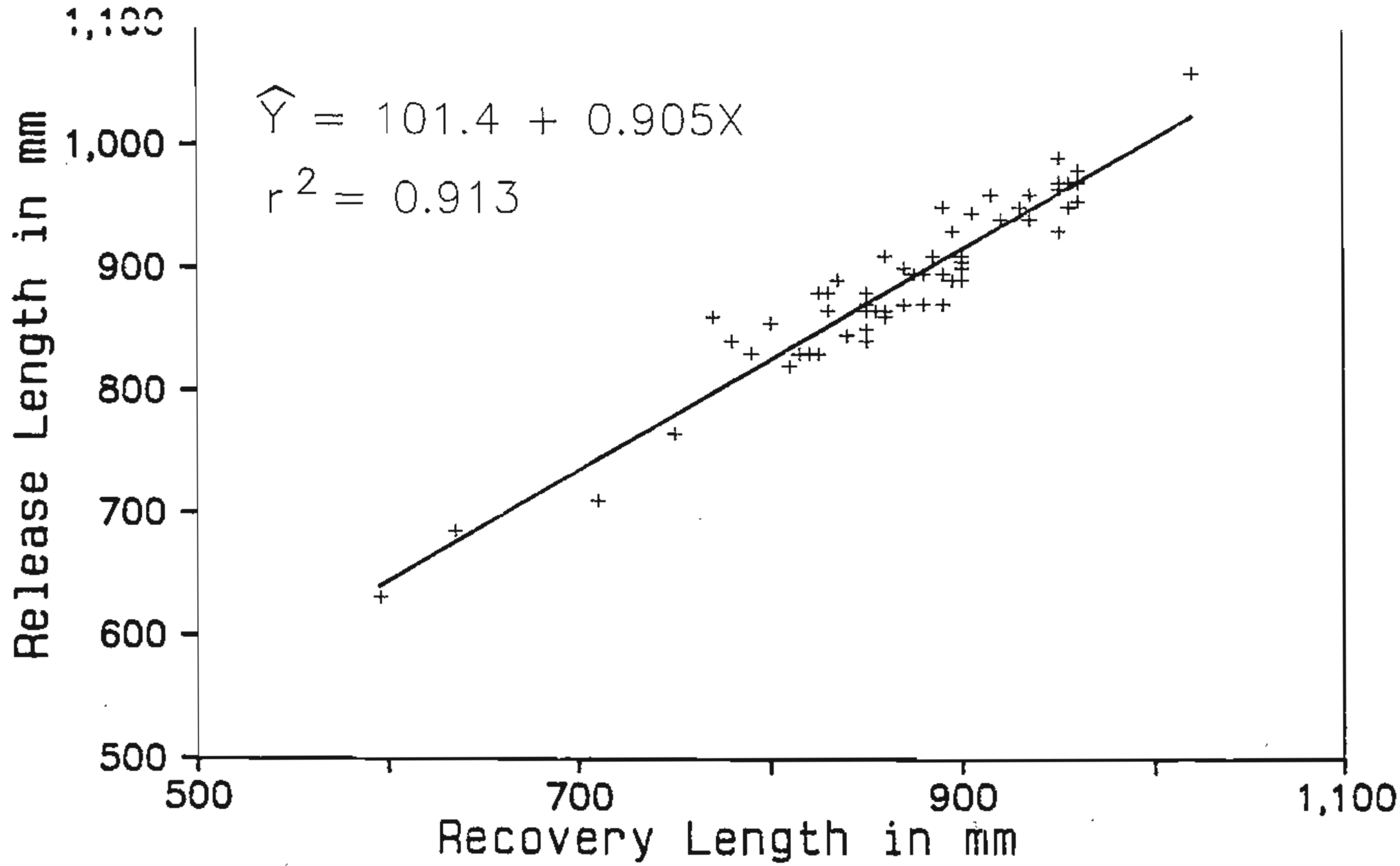

Figure 2. Recovery length (mm) versus release length (mm) of chinook salmon tagged in the Chena River during 1988 and the calculated regression line.

randomness of the releases (B versus C in Figure 3). The recaptures were tested by partitioning the releases into those which were recovered and those which were not and comparing the cumulative distributions of their lengths (B versus A in Figure 3). Ten chinook salmon were recovered during carcass surveys without a tag but a finclip indicating that they had been tagged during the gill net operation. These fish were extracted from the tag releases by converting their recovery length to a release length and selecting a fish of the same sex and similar size from those released during the temporal stratum indicated by their finclip combination.

Tests for comparing the cumulative distributions of the lengths for the above comparisons were both significant ($P < 0.01$). This is evident from a visual comparison of the distributions (Figure 3) where there is a complete absence of fish less than 821 mm in length for the tagged fish which were recovered even though fish less than 821 mm in length were present in both the release and recovery samples. Obviously chinook salmon greater than 820 mm in length had a higher probability of recovery.

A random sample of the population either at the time of release or at the time of recapture is required for a Petersen-type population estimate. The previous analyses indicate that this requirement was not met. Petersen estimates for each sex were considered as it is clear that nearly all the fish less than 821 mm in length are males. The sex composition of the tagged fish which were recovered (80% female and 20% male) was significantly different ($X^2 = 7.8$, 1 df, $P < 0.01$) from the tagged fish which were not recovered (57% female and 43% male) and significantly different ($X^2 = 8.1$, 1 df, $P < 0.01$) from the untagged fish examined during carcass surveys (59% female and 41% male). This was not judged to be satisfactory, however, since there were only 10 valid tag recoveries for males and an estimate based upon only 10 recoveries would have an unacceptably large variance. Another possibility was to limit the length of the fish in the release and recovery groups to those observed in the tag recoveries. This was the approach used.

To determine the minimum length to include in the estimate, sequential K-S tests were preformed comparing the cumulative distributions of the two groups described previously (B versus C and B versus A). Tests were first performed for fish with a release length greater than 840 mm; both tests were not significant ($P > 0.49$). This was continued with the length of acceptance decreased by 10 mm each iteration. The critical length above which the cumulative distributions were significantly different ($P > 0.10$) was 760 mm for the comparison of B and A and 780 mm for the comparison of B and C. Therefore,

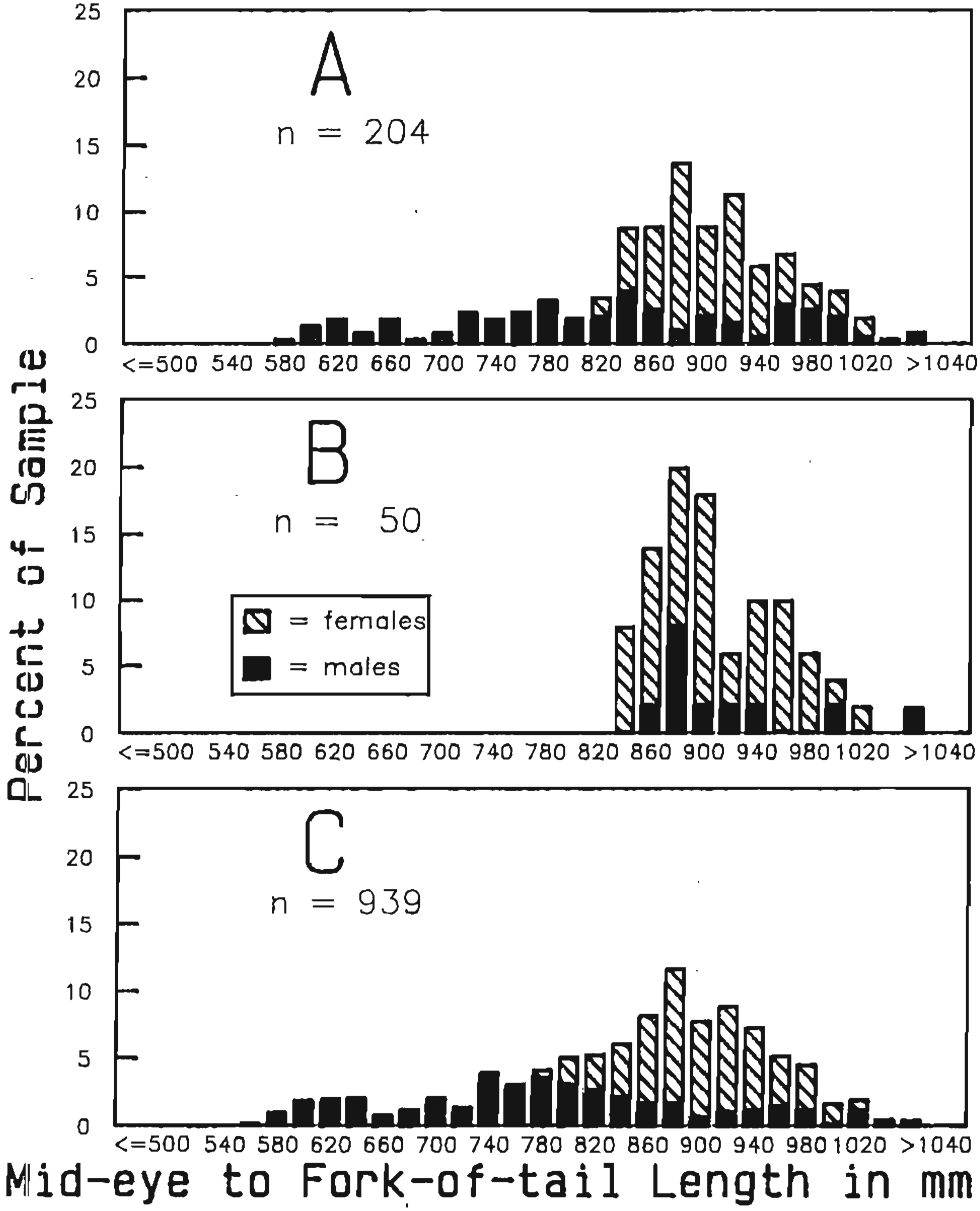

Figure 3. Length frequencies of chinook salmon which were: (A) tagged during gillnetting but not recovered during the carcass survey; (B) tagged during gillnetting and recovered during the carcass survey; and (C) never tagged during gillnetting but examined during the carcass survey, for the Chena River in 1988.

subsequent analyses were limited to chinook salmon greater than 780 mm in length (at time of release).[2]

Constant probabilities of capture at times of tagging and recapture are important assumptions necessary for Petersen-type abundance estimates (Seber 1982). When tagging and recovery occur over an extended period of time these assumptions are often violated. The tagging data (Appendix C and D) were tested to determine if they were consistent with these assumptions. Two chi-square tests described by Seber (1982, pages 438-439) were used to test these hypotheses.

The first test examined whether tagged chinook salmon greater than 780 mm in length had the same probability of recapture over the duration of tagging. Because of the few tag releases in strata 1 and 5 (Table 4a), strata 1 and 2 and 4 and 5 were combined (Table 4b). The probability of recapture increased for tagged fish > 780 mm in length throughout the period of release (Table 4b). The tag recovery rates for fish released in strata 1 and 2 were not significantly different (X^2 = 0.8, 1 df, $P > 0.25$). Therefore, strata 1 and 2 were combined. The recovery rate of the combined strata was significantly different from stratum 3 (X^2 = 4.1, 1 df, $P < 0.05$).

Even though tag recovery occurred during a 15-day period, the recovery data from carcass surveys were not stratified by time but were stratified by river section. The Chena River was stratified into three sections: (1) MCD to Grange Hall Road (GHR); (2) GHR to South Fork; and (3) South Fork to 3 miles up the East Fork. The tag recovery rate for chinook salmon greater than 780 mm (Appendix D) was not significantly different (X^2 = 0.3, 2 df, $P > 0.85$) between the three river sections. Within each river section, daily tag recovery rates were not significantly different either ($P > 0.90$ for section 1, $P > 0.45$ for section 2, $P > 0.25$ for section 3), which supports the assumption that temporal stratification is unnecessary.

Probabilities of recapture were not constant over the period of release, therefore, a Petersen-type population estimate is not appropriate. A stratified population estimator described by Darroch (1961) which is not predicated on constant probabilities of capture was examined. Other stratified estimators are not appropriate as they require that the number of fish belonging to each release stratum be identified during recovery. Clearly, this is not possible for this experiment as the date a fish (other than a tagged fish) entered the river could not be

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[2]Actually a separate analysis using only females was conducted but the results were no different than for fish > 780 mm in length described in the following paragraphs, i.e., no estimate was possible.

Table 4a. Summary of tag release and recovery data for chinook salmon greater than 780 mm in length (at time of release) by the five temporal strata defined for the Chena River in 1988.

Stratum[1]	Total Tags Released	Number of Tags Recovered	Percent Recovered
1	2	0	0.0%
2	33	4	12.1%
3	89	18	20.2%
4	87	28	32.2%
5	5	0	0.0%

[1] Strata definitions:
1 = Released from 29 June through 4 July,
2 = Released from 5 July through 11 July,
3 = Released from 12 July through 18 July,
4 = Released from 19 July through 25 July,
5 = Released from 26 July through 27 July.

Table 4b. Summary of tag release and recovery data for chinook salmon greater than 780 mm in length (at time of release) by the three temporal strata defined for the Chena River in 1988.

Stratum[1]	Total Tags Released	Number of Tags Recovered	Percent Recovered
1	35	4	11.4%
2	89	18	20.2%
Subtotal	124	22	17.7%
3	92	28	30.4%

[1] Strata definitions:
1 = Released from 29 June through 11 July,
2 = Released from 12 July through 18 July,
3 = Released from 19 July through 27 July.

identified during carcass surveys. When there are equal numbers of release and recovery strata, the stratified estimator is (Seber 1982):

$$\underline{\hat{W}} = D_u M^{-1} \underline{a} \qquad [1]$$

where: $\underline{\hat{W}}$ = a vector with the estimates of the number of untagged chinook salmon in each tagging stratum just after the release of the tagged fish,

D_u = a diagonal matrix of the number of untagged fish observed in each recovery stratum j,

M = a matrix of m_{ij}, the number of tagged fish in each recovery stratum, j, which were released in tagging stratum i, and

$\underline{a}$ = a vector of the number of tagged fish released in tagging stratum i.

If there are more release strata than recovery strata, the stratified estimator is (Seber 1982):

$$\underline{\hat{W}} = D_u [X D_a^{-1} M]^{-1} \underline{v} \qquad [2]$$

where $\hat{W}$, D_u, and M are defined previously, and

D_a = a diagonal matrix of the number of tagged fish released in tagging stratum i,

X = a constraint matrix described in detail in Seber (1982), and

$\underline{v}$ = a vector of zeroes with a last element of 1.

The number of chinook salmon in each stratum at the time of tagging is the sum of the estimated number of untagged fish present and the number of tagged fish released during the stratum. Variance formulae for both estimators are given in Seber (1982) and will not be reported here.

Major assumptions necessary for these estimates are (Seber 1982):

1. All chinook salmon in the j^{th} recovery stratum, whether tagged or untagged, have the same probability of being recovered during carcass surveys.

2. Tagged fish behave independently of one another with regard to moving among strata and eventually being recovered.

3. All tagged fish are recognized as such during recovery.

4. There is no tagging induced mortality.

These estimators are sensitive to the configuration of the input data and, in some instances, they can result in negative population estimates for a particular stratum. This is an indication that the data are not meeting some of the assumptions necessary for the models (Seber 1982). Often this problem can be resolved by pooling appropriate data.

Unfortunately, the gillnet data did not conform to either of these estimators. Approximately 15 different models were examined by pooling the data in different ways or by using different subsets of the data (omitting release-and-recovery data from days on either end of the run) but at least one stratum in each model had a negative estimate. Therefore, it was concluded not possible to estimate population size with the gill net data.

Analysis of Electroshock Tagging Data

On 25 July, an additional 128 chinook salmon were captured and tagged primarily in river section 3 of the Chena River using an electroshocking boat. One of the fish captured had been previously tagged during the gill net operation. This fish was retagged with a new spaghetti tag (#8602) and later recovered during carcass surveys. Since the fish had been first captured by gill net it was treated as a gill net tagged fish and included in the previous analysis.

There were six chinook salmon recovered during carcass surveys with no tag but with a finclip indicating they had been tagged during electroshocking. The procedure used to extract fish recovered during carcass surveys without a tag but with a finclip from the tag releases by gill nets was used to extract these six fish from the tag releases by electroshocking. The length at recovery used was the estimated length at release; same as was done in the previous gill net analysis.

Electroshocking data were first analyzed separately for a population estimate. K-S tests were conducted to determine if release and recovery samples were random with respect to length of the fish. There was a significant difference ($P < 0.01$) between the length distributions of releases which were recovered and those which were not (B versus A in Figure 4). There was not

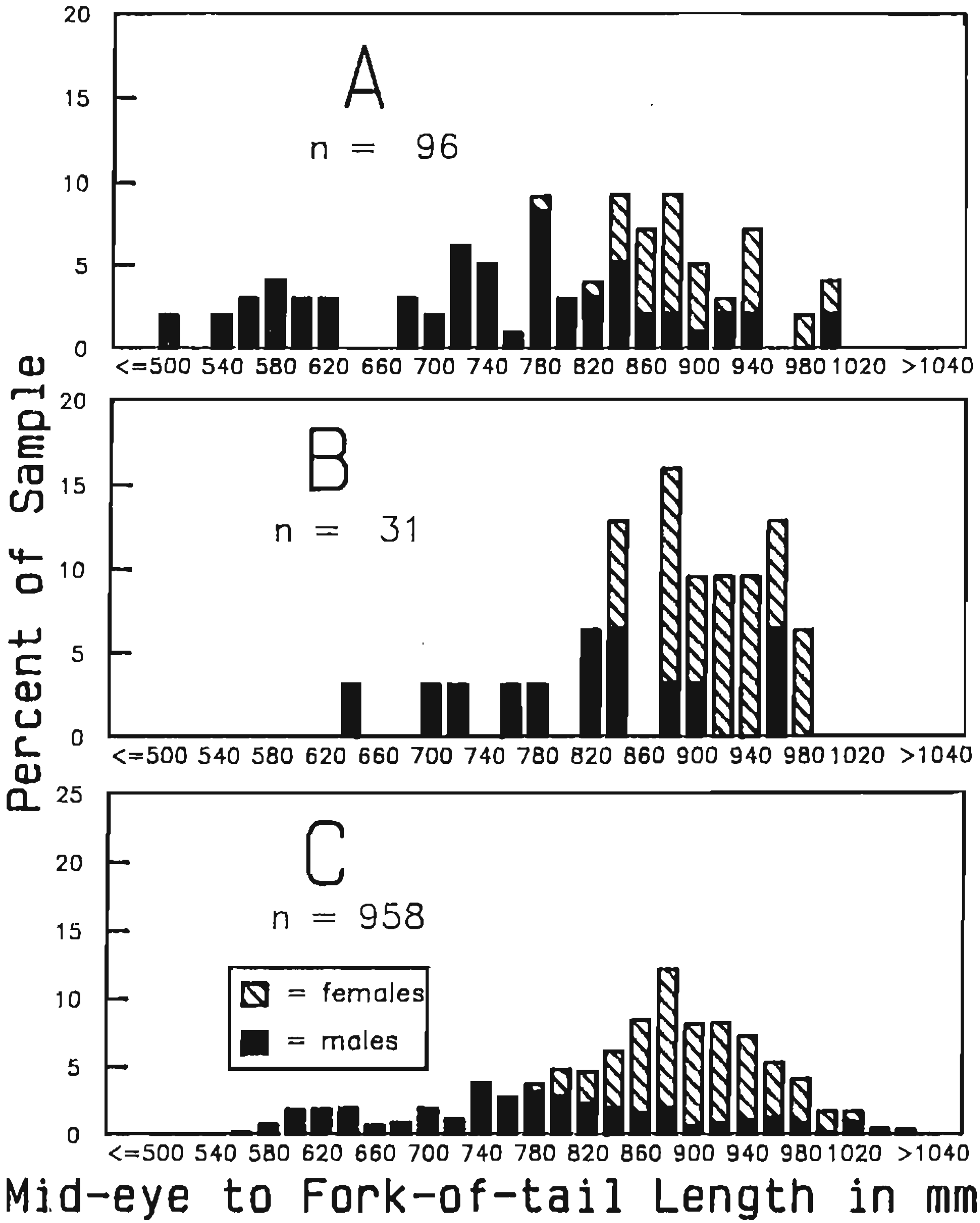


Figure 4. Length frequencies of chinook salmon which were: (A) tagged during electroshocking but not recovered during the carcass survey; (B) tagged during electroshocking and recovered during the carcass survey; and (C) never tagged during electroshocking but examined during the carcass survey, for the Chena River in 1988.

a significant difference (P > 0.23) between the length distributions of the tag recoveries and the untagged fish examined during carcass surveys (B versus C in Figure 4).

Sequential K-S tests were performed as was done for the gill net data to compare the cumulative distributions of groups A and B to determine the minimum length to include in the estimate. The critical length above which the cumulative distributions were not significantly different (P > 0.19) was 780 mm. The cumulative distributions of fish less than or equal to this length were not significantly different (P > 0.48) either. Therefore, subsequent analyses were conducted for two groups of chinook salmon, those less than or equal to 780 mm in length at time of release (small fish) and those greater than 780 mm in length at time of release (large fish).

Temporal changes in probability of capture are not a problem with the fish captured by electroshocking as they were all released on one day. Differences in recovery rates between river sections were examined, however, as was done for gill net data. Chinook salmon tagged during electroshocking were only recaptured in river sections 2 and 3 (Appendix D). Therefore, the data can only be used to estimate the number of fish in those two sections; no estimate for section 1 of the river can be made from electroshocking data.

The tag recovery rate of large chinook salmon (Appendix D) was significantly different (X^2 = 4.1, 1 df, P < 0.03) between river sections 2 and 3. The recovery rate of small chinook salmon (Appendix D) was not significantly different (X^2 = 3.5, 1 df, P > 0.10) between river sections 2 and 3, therefore, the recovery data for these two sections can be pooled. If carcass survey data for 29 July are omitted and the fish that was captured and tagged by both gill net and electroshocking (#8602) is added to the recovery data, the recovery rates between sections 2 and 3 are no longer significant (X^2 = 2.3, 1 df, P> 0.12). The justification for omitting the data from 29 July is that the fish tagged during electroshocking on 25 July had not yet had sufficient time to randomly distribute throughout section 2 by 29 July. The recovery data for large chinook salmon for sections 2 and 3 can now be pooled.

The population in river sections 2 and 3 at the time of tagging (25 July) can now be estimated using a Petersen estimate. Using Chapman's modification to the standard Petersen estimate:

$$\hat{N} = [(M+1)(C+1)/(R+1)] - 1 \qquad [3]$$

The values are: for large fish (> 780 mm in length at release), M=80, C=544, and R=27; for small fish (<= 780 mm in length at release), M=48, C=179, and R=5. Because there were fewer than 50 tag recoveries for each group and less than 10% of the estimated population was tagged, 95% confidence intervals were estimated using the Poisson approximation and Table A1 in Seber (1982).

This results in estimates of the numbers of large and small chinook salmon present in sections 2 and 3 of the Chena River on 25 July of:

1) large fish estimate = 1,576; 95% CI = 1,048 - 2,346

2) small fish estimate = 1,469; 95% CI = 553 - 4,408

3) total population (sections 2 and 3) = 3,045; 95% CI = 1,944 - 4,145

Analysis of Gill Net and Electroshock Data Combined

The release and recovery data from the chinook salmon captured by electroshocking were analyzed to determine if these data could be combined with the gill net tag release and recovery data. The K-S test was used to compare the cumulative length distributions of the fish which were tagged but never recovered for each method of capture (gill net and electroshocking). This was done for tagged fish which were recovered, also. The test for the tagged fish released but never recovered was highly significant ($P < 0.01$) while the test for the tagged fish which were recovered was of borderline significance ($P \approx 0.11$). When the data in the comparisons was restricted to fish greater than 780 mm in length neither test was significant ($P > 0.15$ and $P > 0.83$, respectively).

Males contributed a higher proportion to both electroshocked groups than to the gill net groups (Figure 5). The sex composition of tagged fish which were released by the gill nets but never recovered (43% male and 57% female) was significantly different ($X^2 = 14.1$, 1 df, $P < 0.01$) from that for tagged fish released by electroshocking but never recovered (67% male and 33% female). The sex composition of tagged fish released by the gill nets and recovered during carcass surveys (20% male and 80% female) was significantly different ($X^2 = 3.5$, 1 df, $P < 0.07$) from the tagged fish released by electroshocking and recovered during carcass surveys (42% male and 58% female), also. There were five chinook salmon tagged during electroshocking and recovered that were less than 781 mm in length (compared to none for the gill net group); all five fish were males.

Of the chinook salmon greater than 780 mm in length captured and released (79 fish) by electroshocking, 32.9% (26 fish) were recaptured during carcass surveys. This was not significantly different from the percentage recaptured of the releases in

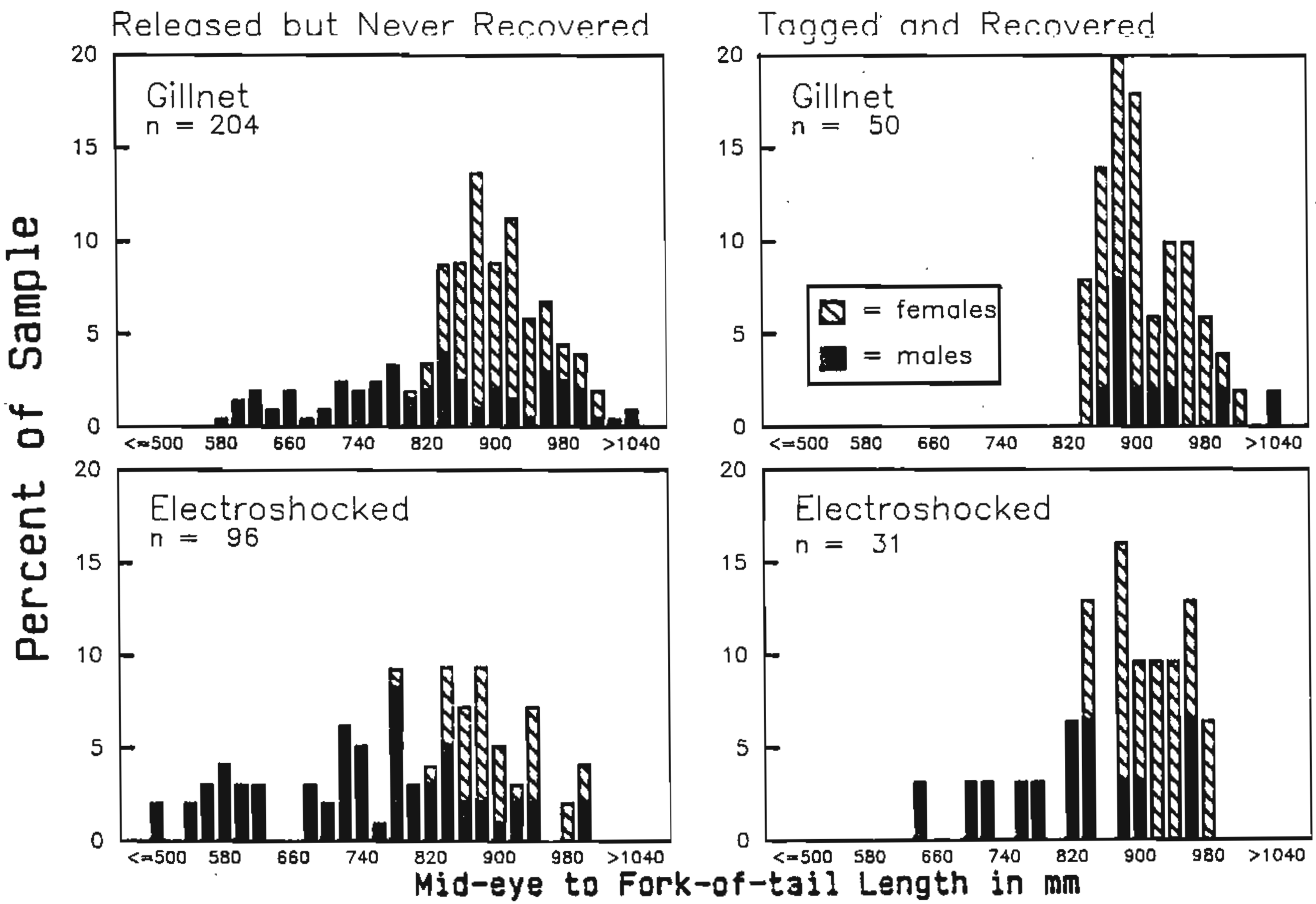


Figure 5. Comparison of tag release and tag recovery length distributions of chinook salmon tagged during gillnetting and tagged during electroshocking in the Chena River during 1988.

stratum 2 (X^2 = 0.7, 1 df, P > 0.40) or stratum 3 (X^2 = 1.3, 1 df, P > 0.24) for chinook salmon greater than 780 mm in length captured by gill nets. The tag recovery rate for large chinook salmon tagged during gillnetting was significantly different (P < 0.01) from the recovery rate for large fish tagged during electroshocking for sections 1 and 2 of the Chena River (Appendix D).

Approximately 10 different models were examined by pooling the electroshocking data with the gill net data in different ways or by using different subsets of both data sets, but at least one stratum in each model had a negative estimate. Pooling the data does not allow the gill net data to be used in the analysis.

Run Timing

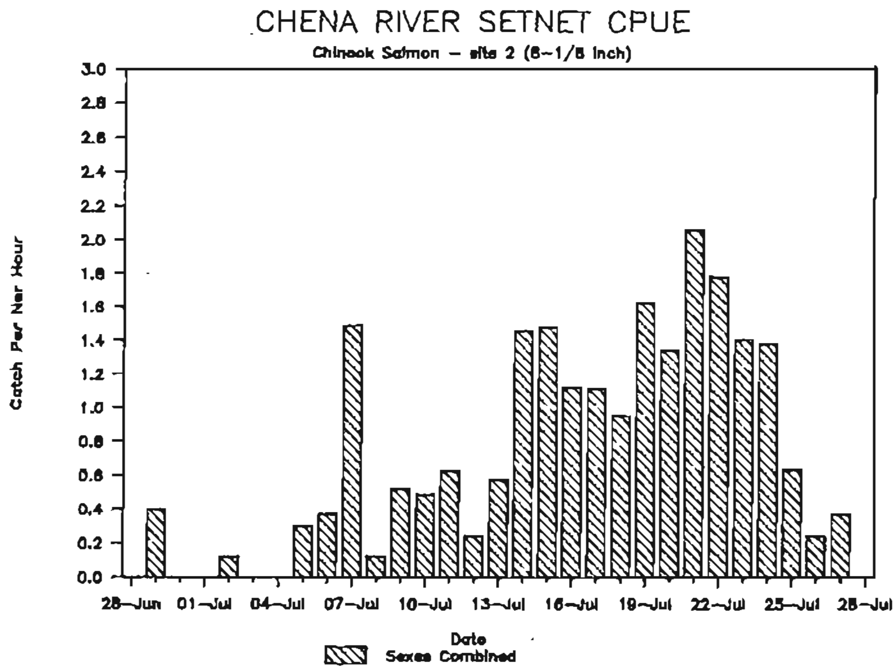
Timing of the Chena River chinook salmon migration was examined using an approach by Mundy (1982, 1984). He developed a time density model to describe salmon migration run timing. The pattern of the migration is described by the mean date of passage (a measure of the central tendency) and the standard deviation (a measure of dispersion). These statistics are calculated from the proportion of the total escapement occurring each day. Further, the median date is the day on which 50% run-passage occurs.

Only CPUE data from large mesh gear fished at site 2 during the standard 8-hour daily period was used to estimate run timing. That net was the most consistently fished, even during periods of high water. As a result the mean day of run passage for chinook salmon (sexes combined) in the Chena River in 1988 was estimated to be 17 July with a standard deviation (SD) of 5.7 days (Figure 6). The median day of the run fell on 18 July. A slight difference in timing by sex was observed: the mean day for males was 15 July (SD = 5.9), 3 days earlier than for females (18 July, SD = 6.1).

Total Spawning Abundance

Aerial survey results revealed the upper end of the Chena River chinook salmon escapement objective (1,700 fish) was achieved in 1988 by the presence on 20 July of 1,643 fish between MCD (RM 45) and the Middle Fork river (RM 97). The later aerial survey of 27 July substantiated this when 1,760 chinook salmon were observed in this same section.

The 1988 mark-and-recapture population estimate for Chena River chinook salmon escapement applies only to river sections 2 and 3, i.e., that area of the river from GHR (RM 60) to 3 miles up the



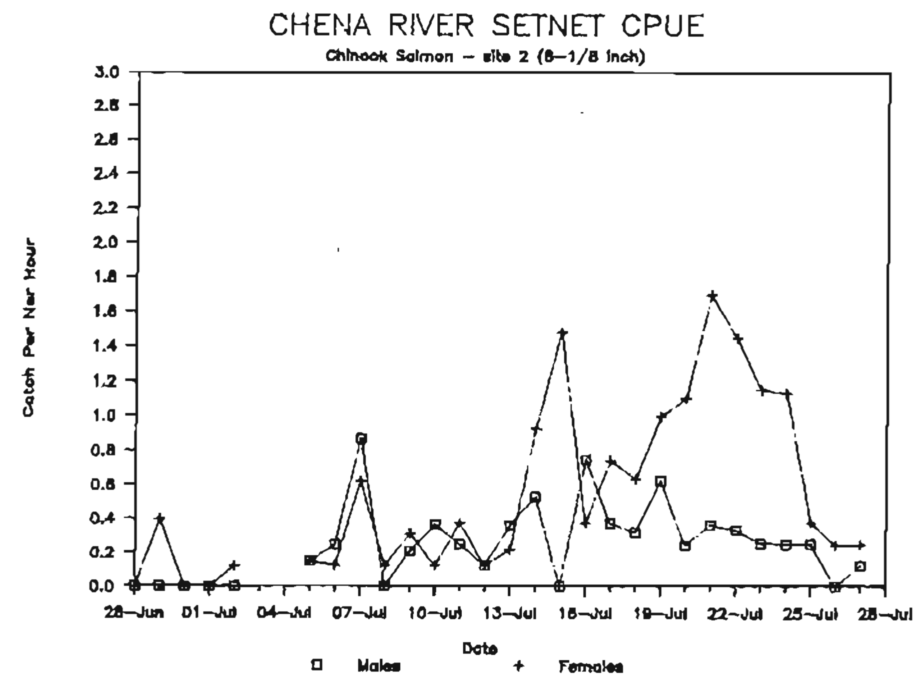


Figure 6. Chinook salmon run timing in the Chena River based upon CPUE of large mesh gill nets at rivermile 16 in 1988.

Middle Fork (RM 100). A method of estimating the population in section 1 (RM 45 to RM 60) is required for a total river estimate. Data from the 20 July aerial survey cannot be used to estimate the proportion of fish in section 1 as fish counts were not broken down in relation to the GHR landmark on that survey. However, observations made on the 27 July survey can be used to evaluate fish distribution in section 1. Data collected on that survey indicated that a conservative estimate of approximately 9% of the chinook salmon observed between MCD and the Middle Fork river were distributed in section 1 (MCD to GHR).

The population estimate for sections 2 and 3 (i.e., GHR to 3 miles up the Middle Fork; RM 60 to RM 100) was 3,045 chinook salmon. Based upon aerial survey observations of 27 July, the expanded total estimate for sections 1, 2 and 3 is 3,346 chinook salmon. This is considered a minimal estimate.

The peak survey estimate (20 July) of 1,966 chinook salmon represents no more than 59% of the total population estimate of 3,346 chinook salmon, while survey results on 27 July (1,879 fish) represent not more than 56% of the total population estimate. Although the 20 July survey was given an overall rating of only "fair", survey conditions were much better than encountered during peak surveys in 1986 or 1987. The "fair" rating in 1988 was primarily due to scattered clouds and slight water turbidity in the lower river, whereas the "fair" ratings in 1986 and 1987 were primarily due to 40-60% of the mainriver channel downstream of the South Fork river being obscured to the observers by dark stained water (Barton 1988). Peak aerial estimates in 1986 and 1987 accounted for approximately 21% and 22%, respectively, of the mark-and-recapture estimates of total abundance in those years.

CONCLUSIONS AND RECOMMENDATIONS

A population estimate of 3,346 fish, while considered minimal, is taken to reflect the general order of magnitude of the 1988 Chena River chinook salmon spawning escapement. Although the proportion of total chinook salmon spawning abundance represented by a peak aerial census varies not only from survey conditions but also by river (Table 5), it is likely that no more than approximately 55-60% of the actual population would be observed in the Chena River on peak surveys given "good" survey conditions. Studies of the Chena River in 1986 and 1987 suggest that peak surveys flown under "fair" conditions of this river represent a substantially smaller percentage of total abundance; on the order of magnitude of 21% to 22%.

Table 5. Comparsion of chinook salmon total estimated spawning populations for selected streams and the proportion represented by an aerial census flown during peak of spawning.

Year	Location		Total Abundance Estimate and Method a	Aerial Census Peak Count	Aerial Census Rating (if known)	Percent of Total Estimate by Aerial Census	Source
1986	Chena River (AK)		9,065 (m/r)	2,031	fair	22.4%	Barton 1987b
1987	Chena River (AK)		6,404 (m/r)	1,312	fair	20.5%	Barton 1988
1988	Chena River (AK)	Surveyor #1	3,346 (m/r)	1,966	fair b	58.8%	This Study
	Chena River (AK)	Surveyor #2	3,346 (m/r)	1,879	good c	56.2%	This Study
1987	Salcha River (AK)		4,771 (m/r)	1,898	fair	39.8%	Skaugstad 1988
1988	Salcha River (AK)		4,562 (m/r)	2,761	good	60.5%	Skaugstad 1989
1987	East Fork Andreafsky River (AK)		2,011 (twr)	1,608	good	80.0%	US/Canada JTC 1987
1988	East Fork Andreafsky River (AK)		1,339 (twr)	1,020	good	76.2%	US/Canada JTC 1988
1986	Big Salmon River (Y.T. CAN)		1,816 (weir)	701	fair	38.6%	Barton 1987b
1987	Big Salmon River (Y.T. CAN)		998 (weir)	747	good	74.8%	Barton 1987a
1985	Clear Creek (AK)		444 (weir)	77	fair d	17.3%	Barton 1987c
1986	Clear Creek (AK)		108 (weir)	47	poor	43.5%	Barton 1987c
1979	Morice River (B.C. CAN)		2,826 (g/s)	1,470		52.0%	Neilson and Geen 1981

a Methods are mark and recapture (m/r); tower counts (twr); weir counts (weir); and, population estimated from replicate ground surveys and stream life (g/s).

b Survey flown by surveyor #1 on 20 July. The "fair" survey rating was primarily due to scattered clouds and slight water turbidity in portion of the survey area, whereas the "fair" ratings in 1986 and 1987 were primarily due to 40-60% of portions of the mainstem river index areas being obscured to observers by dark stained water.

c Survey flown by surveyor #2 on 27 July.

d Survey conditions were rated "fair" but timing of survey was late with regards to peak of spawning.

While more studies of this type could be conducted on the Chena River to refine expansion factors for aerial survey point estimates, it is recommended that studies on this stream be discontinued in 1989. This is in view of the fact that a similar study will again be conducted for a third season in 1989 on the Salcha River. However, if the Chena River is selected for a fourth year of study, it is recommended that population estimates for chinook salmon be based around electroshocking as temporal changes in probability of capture are minimized when using this technique.

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Appendix A. Test gill net daily catch records by mesh size in the Chena River in July 1988.

Date	Fishing Time: Site Number	Mesh Size	Time Set	Time Pulled	Duration Minutes	Duration Hours	Chinook Salmon: Male	Female	Total	Chum Salmon: Male	Female	Total	Remarks
05-Jul	1	5.75	0921	1557	396	6.6	1	0	1	1	0	1	high water (anchor to drug)
06-Jul	1	5.75	0806	1608	482	8.0	0	0	0	0	0	0	
07-Jul	1	5.75	0753	1555	482	8.0	1	0	1	0	0	0	
08-Jul	1	5.75	0810	2400	603 a	10.1	0	0	0	2	0	2	
09-Jul	1	5.75	0001	1559	580 b	9.7	2	0	2	1	0	1	1 sheefish (tagged 11682)
10-Jul	1	5.75	0816	1625	489	8.2	0	0	0	0	0	0	
11-Jul	1	5.75	0815	1610	475	7.9	1	0	1	1	0	1	
12-Jul	1	5.75	0806	1614	488	8.1	0	0	0	0	0	0	
13-Jul	1	5.75	0802	2150	828	13.8	1	0	1	1	0	1	
14-Jul	1	5.75	0816	1548	452	7.5	0	0	0	1	1	2	
15-Jul	1	5.75	0759	1606	487	8.1	1	0	1	0	1	1	
16-Jul	1	5.75	0704	1513	489	8.2	0	0	0	2	0	2	
17-Jul	1	5.75	0821	1602	461	7.7	1	0	1	0	4	4	
18-Jul	1	5.75	0815	2354	939	15.7	0	3	3	6	1	7	
19-Jul	1	5.75	0757	1602	485	8.1	0	0	0	3	0	3	
20-Jul	1	5.75	0740	1549	489	8.2	0	0	0	0	0	0	
21-Jul	1	5.75	0751	1604	493	8.2	1	0	1	4	3	7	
22-Jul	1	5.75	0808	1706	538	9.0	0	0	0	4	1	5	
23-Jul	1	5.75	0803	1551	468	7.8	0	0	0	4	2	6	
24-Jul	1	5.75	0809	1609	480	8.0	0	0	0	0	0	0	
25-Jul	1	5.75	0753	1546	473	7.9	1	0	1	1	1	2	
26-Jul	1	5.75	0806	1617	491	8.2	0	0	0	8	1	9	
27-Jul	1	5.75	0756	1556	480	8.0	0	0	0	0	0	0	
							10	3	13	39	15	54	
28-Jun	2	8.13	1050	1520	270	4.5	0	0	0	0	0	0	
29-Jun	2	8.13	1330	1545	150	2.5	0	1	1	0	0	0	
30-Jun	2	8.13	1030	1500	270	4.5	0	0	0	0	0	0	
01-Jul	2	8.13	1018	1452	274	4.6	0	0	0	0	0	0	
02-Jul	2	8.13	817	1624	487	8.1	0	1	1	0	0	0	
03-Jul	2		—	—	0	0.0							
04-Jul	2		—	—	0	0.0							
05-Jul	2	8.13	0932	1611	399	6.7	1	1	2	0	1	1	
06-Jul	2	8.13	0759	1600	481	8.0	2	1	3	0	0	0	
07-Jul	2	8.13	0758	1601	483	8.1	7	5	12	1	0	1	
08-Jul	2	8.13	0800	2400	960 c	16.0	0	2	2	1	0	1	
09-Jul	2	8.13	0001	1607	575 d	9.6	2	3	5	0	0	0	
10-Jul	2	8.13	0809	1618	489	8.2	3	1	4	0	0	0	
11-Jul	2	8.13	0820	1618	478	8.0	2	3	5	0	0	0	
12-Jul	2	8.13	0800	1608	488	8.1	1	1	2	0	0	0	
13-Jul	2	8.13	0806	2156	830	13.8	5	3	8	0	0	0	
14-Jul	2	8.13	0810	1542	452	7.5	4	7	11	0	0	0	
15-Jul	2	8.13	0806	1612	486	8.1	0	12	12	0	0	0	
16-Jul	2	8.13	0657	1458	481	8.0	6	3	9	0	0	0	
17-Jul	2	8.13	0828	1632	484	8.1	3	6	9	0	0	0	2 chinook morts
18-Jul	2	8.13	0806	2350	944	15.7	5	10	15	0	0	0	
19-Jul	2	8.13	0806	1606	480	8.0	5	8	13	0	0	0	
20-Jul	2	8.13	0734	1544	490	8.2	2	9	11	1	0	1	
21-Jul	2	8.13	0757	1612	495	8.3	3	14	17	0	0	0	
22-Jul	2	8.13	0801	1700	539	9.0	3	13	16	2	0	2	
23-Jul	2	8.13	0809	1558	469	7.8	2	9	11	2	0	2	1 chum escaped; 1 chum mort
24-Jul	2	8.13	0803	1601	478	8.0	2	9	11	0	0	0	
25-Jul	2	8.13	0757	1552	475	7.9	2	3	5	0	0	0	
26-Jul	2	8.13	0802	1613	491	8.2	0	2	2	0	0	0	
27-Jul	2	8.13	0801	1602	481	8.0	1	2	3	0	0	0	
							61	129	190	7	1	8	

-Continued-

		Fishing Time					Chinook Salmon			Chum Salmon			
Date	Site Number	Mesh Size	Time Set	Time Pulled	Duration Minutes	Duration Hours	Male	Female	Total	Male	Female	Total	Remarks
30-Jun	3	5.75	1135	1505	210	3.5	0	0	0	0	0	0	
01-Jul	3		—	—	0	0.0							
02-Jul	3	5.75	0810	1606	476	7.9	1	0	1	0	0	0	
03-Jul	3		—	—	0	0.0							
04-Jul	3		—	—	0	0.0							
05-Jul	3	5.75	0939	1625	406	6.8	0	0	0	0	0	0	
06-Jul	3	5.75	0753	1551	478	8.0	1	0	1	0	1	1	1 chinook recap
07-Jul	3	5.75	0807	1608	481	8.0	0	0	0	0	0	0	1 chinook recap
08-Jul	3	5.75	0755	2400	588 e	9.8	1	0	1	1	0	1	
09-Jul	3	5.75	0001	1616	574 f	9.6	2	0	2	3	0	3	
10-Jul	3	5.75	0803	1611	488	8.1	0	0	0	0	0	0	
11-Jul	3	5.75	0824	1624	480	8.0	1	0	1	0	0	0	1 chinook recap
12-Jul	3	5.75	0757	1559	482	8.0	3	1	4	0	0	0	
13-Jul	3	5.75	0811	2206	820 g	13.7	2	0	2	0	0	0	1 chinook mort
14-Jul	3	5.75	0806	1536	450	7.5	1	1	2	0	0	0	
15-Jul	3	5.75	0810	1618	488	8.1	2	0	2	0	0	0	
16-Jul	3	5.75	0652	1447	475	7.9	0	0	0	0	0	0	
17-Jul	3	5.75	0835	1650	495	8.3	0	0	0	0	0	0	
18-Jul	3	5.75	0802	2320	918	15.3	2	0	2	0	0	0	
19-Jul	3	5.75	0817	1616	479	8.0	0	1	1	2	1	3	
20-Jul	3	5.75	0731	1540	489	8.2	1	1	2	0	0	0	
21-Jul	3	5.75	0803	1621	498	8.3	3	0	3	6	2	8	
22-Jul	3	5.75	0756	1652	536	8.9	1	1	2	5	0	5	
23-Jul	3	5.75	0815	1608	473	7.9	0	0	0	0	1	1	
24-Jul	3	5.75	0757	1555	478	8.0	0	0	0	0	0	0	
25-Jul	3	5.75	0804	1601	477	8.0	0	0	0	1	0	1	
26-Jul	3	5.75	0759	1608	489	8.2	0	0	0	2	1	3	
27-Jul	3	5.75	0806	1612	486	8.1	0	0	0	1	0	1	
							21	5	26	21	6	27	
13-Jul	4	8.13	0919	2218	779	13.0	2	5	7	0	0	0	
14-Jul	4	8.13	0758	1530	452	7.5	0	3	3	0	0	0	
15-Jul	4	8.13	0816	1624	488	8.1	2	4	6	0	0	0	
16-Jul	4	8.13	0648	1434	466	7.8	1	2	3	0	0	0	
17-Jul	4	8.13	0841	1706	505	8.4	0	1	1	0	0	0	
18-Jul	4	8.13	0757	2300	903	15.1	1	4	5	2	0	2	
19-Jul	4	8.13	0823	1619	476	7.9	0	0	0	0	0	0	
20-Jul	4	8.13	0727	1533	486	8.1	1	0	1	0	0	0	
21-Jul	4	8.13	0820	1630	490	8.2	1	1	2	0	1	1	
22-Jul	4	8.13	0752	1646	534	8.9	0	1	1	0	0	0	
23-Jul	4	8.13	0822	1617	475	7.9	0	0	0	1	0	1	
24-Jul	4	8.13	0754	1545	471	7.9	0	0	0	0	0	0	
25-Jul	4	8.13	0809	1612	483	8.1	0	0	0	4	0	4	
26-Jul	4	8.13	0755	1600	485	8.1	0	0	0	1	0	1	
27-Jul	4	8.13	0812	1620	488	8.1	0	0	0	0	0	0	
							8	21	29	8	1	9	
				Grand Total			100	158	258	75	23	98	

a Actual fishing time was 0810-1618 and 2205-2400 hrs.
b Actual fishing time was 0001-0140 and 0759-1559 hrs.
c Actual fishing time was 0800-1612 and 2210-2400 hrs.
d Actual fishing time was 0001-0135 and 0807-1607 hrs.
e Actual fishing time was 0755-1558 and 2215-2400 hrs.
f Actual fishing time was 0001-0130 and 0812-1616 hrs.
g Actual fishing time was 0811-1530. Reset downstream 50 ft @ 1545-2206 hrs.

Appendix B. Tagged chinook salmon recovered during the carcass survey of the Chena River in 1988 and used in the release-recovery length analysis.

#	Survey Date	Tag Number[1]	Fin Clip A	Fin Clip LP	Fin Clip RP	Fin Clip AN	Rel. Sex	Release Length (mm)	Rec. Sex	Recovery Length (mm)
1	12-Aug	8550			x		f	950	f	890
2	05-Aug	8551			x		f	970	f	950
3	10-Aug	8597			x		f	910	f	900
4	11-Aug	8598			x		f	895	f	875
5	05-Aug	8603			x		f	880	f	830
6	05-Aug	8624			x		m	840	f	510[2]
7	11-Aug	8626			x		f	870	f	870
8	05-Aug	8629			x		f	965	f	950
9	04-Aug	8631			x		f	940	f	935
10	10-Aug	8637			x		f	840	f	780
11	11-Aug	8641			x		f	880	f	850
12	10-Aug	8646			x		f	870	f	850
13	10-Aug	8653			x		f	900	f	870
14	10-Aug	8666			x		f	940	f	920
15	04-Aug	8670			x		f	950	f	955
16	10-Aug	8673			x		f	830	f	815
17	04-Aug	11676	x	x			f	890	f	835
18	05-Aug	11678	x	x			f	930	f	950
19	29-Jul	11692	x		x		m	1,020	f	990[2]
20	03-Aug	11710	x		x		f	860	f	770
21	09-Aug	11727	x		x		f	855	f	800
22	04-Aug	11737	x		x		f	895	f	880
23	04-Aug	11745	x		x		f	870	f	890
24	29-Jul	11754	x		x		f	940	f	935
25	05-Aug	11783	x		x		f	845	f	840
26	09-Aug	11792	x		x		f	895	f	890
27	05-Aug	11799	x		x		f	980	f	960
28	03-Aug	11802	x		x		f	865	f	850
29	29-Jul	11808	x		x		f	900	f	900
30	08-Aug	11813	x				f	960	f	915
31	05-Aug	11827	x				f	830	f	820
32	04-Aug	11828	x				f	890	f	895
33	09-Aug	11829	x				f	930	f	895
34	11-Aug	11833	x				f	945	f	905
35	03-Aug	11834	x				f	910	f	860
36	03-Aug	11836	x				f	970	f	960
37	02-Aug	11841	x				f	850	f	850
38	02-Aug	11851	x				f	960	f	935
39	04-Aug	11853	x				f	830	f	820
40	02-Aug	11858	x				f	905	f	900

-Continued-

Appendix B. (p. 2 of 2)

#	Survey Date	Tag Number[1]	Fin Clip A	LP	RP	AN	Rel. Sex	Release Length (mm)	Rec. Sex	Recovery Length (mm)
41	02-Aug	11859	x				f	940	f	935
42	06-Aug	11868	x				f	950	f	930
43	09-Aug	11870	x				f	970	f	955
44	12-Aug	11876	x				f	990	f	950
45	10-Aug	11882	x				f	865	f	860
46	09-Aug	11885	x				f	865	f	855
47	02-Aug	11887	x				f	955	f	960
48	08-Aug	11891	x				f	870	f	850
49	05-Aug	11900	x				f	830	f	825
50	09-Aug	11902	x				f	840	f	850
51	06-Aug	8545			x		m	630	m	595
52	10-Aug	8556			x		m	685	m	635
53	05-Aug	8563			x		m	765	m	750
54	05-Aug	8568			x		m	830	m	790
55	05-Aug	8586			x		m	710	m	710
56	04-Aug	8602[3]	x		x		m	860	m	860
57	04-Aug	8608			x		m	950	m	955
58	05-Aug	8617			x		m	890	m	900
59	11-Aug	8621			x		m	880	m	825
60	04-Aug	8665			x		m	820	m	810
61	04-Aug	11675	x	x			m	865	m	830
62	03-Aug	11724	x		x		m	910	m	885
63	05-Aug	11774	x		x		m	870	m	880
64	03-Aug	11894	x				m	1,060	m	1,020
65	05-Aug	11899	x				f	935	m	925[2]

[1] Tags numbers 8000 to 9000 were placed during electroshocking and tag numbers greater than 11000 were placed during gillnetting.

[2] Omitted from the analysis because of discrepency between the sexes.

[3] Was originally tag 11759 (890 mm) and retagged when caught during electroshocking. Included with gillnet fish.

Appendix C. Number of chinook salmon tagged during gillnet sampling, by date, and number of tag recoveries during the carcass survey from each daily release for the Chena River in 1988.

Release Date	Number of Valid Tag Releases <=780 mm	>780 mm	Total	Number of Tags Recovered <=780 mm	>780 mm
29-June	0	1	1	0	0
30-June	0	0	0	0	0
01-July	0	0	0	0	0
02-July	1	1	2	0	0
03-July	0	0	0	0	0
04-July	0	0	0	0	0
05-July	1	2	3	0	0
06-July	1	3	4	0	0
07-July	2	11	13	0	2
08-July	1	2	3	0	1
09-July	4	5	9	0	0
10-July	0	4	4	0	1[1]
11-July	1	6	7	0	0
12-July	3	3	6	0	0
13-July	6	11	17	0	3
14-July	2	14	16	0	3
15-July	2	19	21	0	3
16-July	1	11	12	0	2[1]
17-July	0	9	9	0	1
18-July	3	22	25	0	6[1]
19-July	1	13	14	0	2
20-July	3	11	14	0	7[2]
21-July	2	21	23	0	8
22-July	3	16	19	0	3
23-July	0	11	11	0	4[3]
24-July	0	11	11	0	4[3]
25-July	1	4	5	0	0
26-July	0	2	2	0	0
27-July	0	3	3	0	0
Totals	38	216	254	0	50
25-July[4]	48	79	127	5	26

[1] Includes one fish assigned a release date based on fin clip combination and recovery length.

[2] Includes three fish assigned a release date based on fin clip combination and recovery length.

[3] Includes two fish assigned a release date based on fin clip combination and recovery length.

[4] Data for electroshocking releases.

Appendix D. Number of chinook salmon examined by date and river section and number of tags recovered during the carcass survey of the Chena River in 1988.

Survey Area[1]	Survey Date	Number of Fish Examined <=780 mm	Number of Fish Examined >780 mm	Number of Fish Examined Total	Number of Tags Recovered <=780 mm GN[2]	<=780 mm ES[3]	>780 mm GN[2]	>780 mm ES[3]
1	3-Aug	19	107	126	0	0	7	0
1	8-Aug	10	61	71	0	0	3	0
	Subtotal	29	168	197	0	0	10	0
2	29-July	34	64	98	0	0	5	0
2	02-Aug	32	90	122	0	0	6	0
2	04-Aug	29	141	170	0	0	9	6
2	09-Aug	22	63	85	0	0	7	0
2	10-Aug	29	48	77	0	1	1	6
	Subtotal	146	406	552	0	1	28	12
3	05-Aug	35	97	132	0	3	9	9
3	06-Aug	21	51	72	0	1	1	0
3	11-Aug	7	41	48	0	0	1	4
3	12-Aug	4	13	17	0	0	1	1
	Subtotal	67	202	269	0	4	12	14
	Totals	242	776	1,018	0	5	50	26

[1] Area Definitions:
1 - dam to Grange Hall Road,
2 - Grange Hall Road to South Fork,
3 - South Fork to 3 miles up East Fork.

[2] Fish caught and tagged during gillnetting.

[3] Fish caught and tagged during electroshocking.